IV. "On the Nature of the Light emitted by heated Tourmaline." By Balfour Stewart, Esq., M.A. Communicated by J. P. Gassiot, Esq. Received May 22, 1860.

Some months ago I had the honour of submitting to the Royal Society a paper on the light radiated by heated bodies, in which it was endeavoured to explain the facts recorded by an extension of the theory of exchanges.

Having mentioned the difficulty which I had in maintaining the various transparent substances at a nearly steady red heat for a sufficient length of time in experiments demanding a dark background, Professor Stokes suggested an apparatus by means of which this difficulty might be overcome; and it is owing to his kindness in doing so that I have been enabled to lay these results before the Society.

The apparatus consists of a thick, spherical, cast-iron bomb, about 5 inches in external and 3 inches in internal diameter—the thickness of the shell being therefore 1 inch. It has a cover removeable at pleasure. There is a small stand in the inside, upon which the substance under examination is placed, and when so placed it is precisely at the centre of the bomb. Two small round holes, opposite to one another, viz. at the two extremities of a diameter, are bored in the substance of the shell. If, therefore, the substance placed upon the stand be transparent, and have parallel surfaces, by placing these surfaces so as to front the holes, we are enabled to see through the substance, and consequently through the bomb. Let the bomb with the substance on the stand be heated to a good red heat, and then withdrawn from the fire and allowed to cool. It is evident that the cooling of the substance on the stand will proceed very slowly, as it is almost completely surrounded with a red-hot enclosure. It is also evident that, by placing the bomb in a dark room, we may view the transparent substance against a dark background. By this method of experimenting, therefore, the difficulty above alluded to is overcome.

Before describing the experiment performed on tourmaline, it may be well to state what result the theory of exchanges would lead us to expect when this mineral is heated, and we shall perceive at the same

time the importance of the experiment with tourmaline as a test of the theory. When a suitable piece of tourmaline, with its faces cut parallel to the axis, is used to transmit ordinary light, the light which it transmits is nearly completely polarized, the plane of polarization depending on the position of the axis. The reason of this is, that if we resolve the incident light into two portions, one of which consists of light polarized in a plane perpendicular to the axis of the crystal, and the other of light polarized in a plane parallel to the same axis, nearly all the latter is absorbed, while a notable proportion of the former is allowed to pass.

Suppose now that such a piece of tourmaline is placed in a red-hot enclosure; the theory of exchanges, when fully carried out, demands that the light transmitted by the tourmaline, say in a direction perpendicular to its surface, *plus* the light radiated by the tourmaline in that direction, *plus* the small quantity of light reflected by the surface of the tourmaline in that direction, shall together equal in quantity and quality that which would have proceeded in the same direction from the wall of the enclosure alone, supposing the tourmaline to have been removed. Let us neglect the small quantity of light which is reflected from the surface of the tourmaline, and, standing in front of it, analyse with our polariscope the light which proceeds from it. This light consists of two portions, the transmitted and the radiated, both of which together ought to be equal in quality and intensity to that which would reach our polariscope from the enclosure alone were the tourmaline taken away. But the light which would fall on our polariscope from the enclosure alone would not be polarized; hence the whole body of light which falls upon it from the tourmaline, and which is similar in quality to the former, ought not to be polarized. Now part of this light, or that which is transmitted by the tourmaline, is polarized; hence it follows, in order that the whole be without polarization, that the light which is radiated should be partially polarized in a direction at right angles to that which is transmitted.

Another way of stating this conclusion is this. The light which the tourmaline radiates is equal to that which it absorbs, and this equality holds separately for light polarized in a plane parallel to the axis of the crystal, and for light polarized in a plane perpendicular to the same.

The experiment was made with a piece of brown tourmaline having a few opake streaks, procured from Mr. Darker of Lambeth. It was placed in a graphite frame between two circular holes made as above described in opposite sides of the bomb, the diameter of the holes being about $\frac{3}{10}$ths of an inch. On looking in at one of these holes you could thus see through the tourmaline and the opposite hole, or, in other words, see quite through the bomb. An arrangement was also made by which part of the tourmaline might be viewed with the graphite behind it.

The apparatus thus prepared was heated to a red or yellow heat in the fire, placed on a brick in a dark room, and the tourmaline viewed by a polariscope which Mr. Gassiot kindly lent me. The following was the appearance of the experiment:—

Without the polariscope the transparent parts of the tourmaline were slightly less radiant than the field around them. When the polariscope was used, the light from the transparent portions of the tourmaline was found to vary in intensity as the instrument was turned round. No change of intensity could be observed in the light radiated by the opake streaks of the tourmaline, or by the graphite.

The light from the transparent portions was therefore partially polarized. The polariscope was then brought to its darkest position, and a light from behind allowed to pass through the tourmaline. The light was distinctly visible in this position, but by turning round the polariscope about 90° it became eclipsed. The mean of four sets of experiments made the difference between the position of darkness for the two cases $88\frac{1}{2}°$. It appears, therefore, that the light radiated by the tourmaline was partially polarized in a plane at right angles to that which was transmitted by it. It was also ascertained that the light from the tourmaline which had the graphite behind it gave no trace of polarization.